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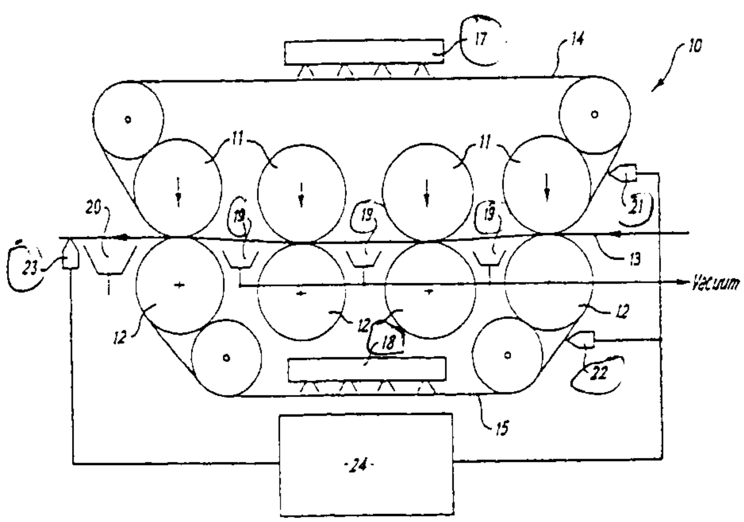

(57) Abstract

A press section of a papermachine has upper and lower press felts (14, 15). Electrical conductivity sensors (21, 22) measure the electrical conductivity of the felts before entry to a press section. A further electrical conductivity sensor (23) senses the electrical conductivity of a paper web (13) as it emerges from the press section. Measurements are also taken of the flow of cleaning showers (17, 18) applied to the felts, and of water removed by the dewatering devices (19) in the press section, and appropriate signals corresponding to these values are applied to a processor (24), which determines a material balance in accordance with a procedure set out in the description.

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METHOD AND APPARATUS FOR MONITORING WATER BALANCE IN A PAPERMACHINE

This invention relates to a method and apparatus for monitoring the water balance in a papermachine, in particular in the press section of a papermachine.

In the press section of a papermachine, the wet fibre web is pressed between cylindrical rolls. Press fabrics are passed through the press nips with the web to cushion the web and to absorb water squeezed from the web. A series of press nips acts upon the web before it leaves the press section to pass to the dryer section of the papermachine.

The water removed from the paper web is partly absorbed by the press fabrics (usually one is provided on each face of the paper web), and the remainder is expelled mechanically from the last nip of the press section to be caught in a collection trough. After leaving the press section the press fabric is treated with additional water by showers to clean, condition and lubricate the fabric. The press fabric is then passed over a vacuum area, or one or more slots, such as Uhle boxes, which causes water to migrate to the surface of the fabric where it is removed by mechanical means.

The press section is intended to remove the maximum amount of water without compromising the quality of the paper web produced. The

amount of water removed is dependent on the nip pressure, the water absorbtion capacity of the press fabric, and the ability of the press rolls to carry water away from the press nip to the collection trough.

The water absorbtion capacity of the press fabric depends upon the water volume received from the cleaning sprays, the water removal capacity of the vacuum dewatering device, the cleanliness of the press fabric and the design characteristics of the press fabric.

At present it is not possible to know dryness of the paper web as it leaves each press nip or as it finally enters the dryer section. To measure the water content directly requires that the sheet be broken, and the machine be out of use for a costly period of downtime. Indirect measurement of the water content of the web requires that a material balance be determined by measuring water flow from the collection troughs, vacuum dewatering devices, and the water content remaining in the press fabric. The latter is measured using a microwave based moisture meter which is manually pressed into the fabric and moved across the width of the machine. In addition the water content entering press section must be measured or assumed.

Because the carrying out of these material balance procedures require expertise and time, they are not normally carried out except under special circumstances. Consequently, during the normal running of the

papermachine there are many unknowns which prevent optimisation of the water removal process.

The unknowns include the effect of press loading on distribution of water flow into the fabric and into the collection trough and overall removal; the effect of the fabric shower flow on the distribution of water flow and overall water removed; the effect of upstream conditions on water removed in the press section; the effect of the paper basis weight on water removal in the press section; the effect of fabric cleanliness on water flow and overall removal; the effect of vacuum levels, dwell time and airflow on water flow and overall removal; the effect of needle jet shower pressures on water flow and overall removal; the effect of roll cover hardness on water flow and overall removal; and the effect of press fabric design on water flow and overall removal.

US Patent 3,655,980 proposes measuring the drainage rate from slurry along the length of a forming wire, using a radiation source and radiation detectors. In US 3,724,957, the concentration of an optically active substance is measured using photoelectric detectors to determine the concentration of pulp and clay in a papermaking slurry, while US 3,860,168 uses a nucleonic detector to monitor the weight of paper sheet. Moisture sensors are used in US 5,093,795, 5,262,955 and 5,286,348. The first two measure the moisture content profile and adjust the moisture content

by adding water or steam to the web, and in the other an infra red sensor is used on the web emerging from the last dryer in a papermaking machine.

In US 4,752,356 the slurry is sampled at the wet end of a papermachine to determine the total organic carbon present as a measure of the requirement for cationic additive materials to neutralise anionic contaminants in the papermaking process, and in US 5,330,621 cellulose pulp slurry is continuously analysed to determine elemental constituents, by gamma neutron activation analysis or carbon content analysis. The measurements are not made on the papermachine during a papermaking process.

None of the measurement methods meet the requirements for continuous material balance monitoring during papermachine operation.

It is accordingly an object of this invention to provide a method and apparatus for monitoring the water balance in a papermachine which enables the monitoring to be carried out whilst the machine is operating, and preferably on a continuous or frequent basis.

According to the invention, a method of monitoring the water balance in a papermachine comprises measuring the electrical conductivity of the water entering a press means entrained in one or more press felts, separately measuring the electrical conductivity of the water entrained in the paper web on leaving the press means, and comparing the measured

electrical conductivities to determine the material balance.

The invention also provides apparatus for monitoring the water balance in a papermachine comprising first measuring means for measuring the electrical conductivity of the water entering a press means entrained in one or more press felts, second measuring means for measuring the electrical conductivity of the water entrained in the paper web on leaving the press means, and means for comparing the measured electrical conductivities to determine the material balance.

The press means may comprise the entire press section of a papermachine, composed of a series of roller nips, or may comprise a discrete roller nip, where each nip in a press section is for example treated as a separate press means for the purposes of determining the material balance.

The measuring means may each comprise an electrohydrodynamic induction flow meter, as disclosed in US 3,528,287.

If a measurement is made of a specific ion concentration such as Cl^- or SO_3^{--} in each of the input and output streams, a material balance could be determined. Specific ion electrodes have problems with cost, maintenance and excessive specificity. The present invention uses the linear relationship between the concentration of typical papermachine ions and the resulting electrical conductivity and substitutes conductivity for a

specific ion concentration. Conductivity measures the total of all ions which will provide a more consistent measurement. Conductivity measurement is simple and requires unsophisticated instrumentation and little day-to-day maintenance.

An embodiment of apparatus according to the invention is illustrated by way of example in the accompanying drawing, which is a diagram illustrating the apparatus.

A press section 10 of a papermachine comprises a plurality of nips provided by upper presser rolls 11 and lower anvil rolls 12. A fibrous paper or tissue web 13 enters the section 10 from the right side of the drawing, and leaves towards the left, after passing through the series of nips.

The web 13 is passed through the press section 10 between an upper press felt 14 and a lower press felt 15, which are cleaned by conditioning sprays 17, 18.

Excess moisture is drawn from the felt/web system following each press nip by a vacuum dewatering device 19, such as a respective Uhle box. At the outlet end of the press section 10, excess water is mechanically discharged, and collected by a collecting trough 20.

Means for measuring the electrical conductivity of entrained water are provided in the form of sensors 21, 22 measuring the conductivity of the upper and lower felts respectively at the input end of the press section 10,

and sensor 23 measuring the conductivity of the paper or tissue web 13 as it leaves the press section.

Signals corresponding to the measured values of conductivity are fed to a processor 24, which in combination with measuring of other factors as set out in the following Example, calculates a material balance.

EXAMPLE

The material balance may be calculated as follows.

Flow gpm x Conductivity IN = Flow x Conductivity OUT

In:

Wet Web + Showers

Wet Web gpm calculated = f(Tons/day, % water - (standard or measured))

Wet Web conductivity measured or calculated from previous press nip

Showers gpm - measured or calculated = f(nozzle size, pressure)

Showers conductivity - measured and weight averaged

Out:

Vacuum dewatering flow and conductivity - measured

Press water flow and conductivity - measured

Wet Web gpm = Wet Web in - Vacuum dewatering out - Press water flow

The unknown is now Wet Web conductivity out and is calculated by solving the equation for conductivity.

WWI gpm x WWI cond + Shower gpm x Shower cond =

Uhle gpm x Uhle cond + Press gpm x Press cond + (WWI gpm - Uhle gpm - Press gpm) x WWO cond

WWI gpm x WWI cond = A

Shower gpm x Shower cond = B

Uhle gpm x Uhle cond = C

Press gpm x Press cond = D

WWI gpm - Uhle gpm - Press gpm = E

A + B = C + D + E x WWO Con

$$\text{WWO cond} = \frac{A + B - C - D}{E}$$

The output (gpm and conductivity) is now known and used as input for the next press nip or as the final exiting conditions.

In addition the conductivity and flow from the collection pans and vacuum removal devices can be analysed to determine what portion is shower water applied to the fabrics and what portion is from water removed from the wet web.

<u>Solids Balance</u>

In:

Wet Web in = WWI gpm x conductivity - from previous stage

Shower in = Shower gpm x conductivity - measured

Out:

Wet Web Out = WWO gpm x conductivity - calculated

Vacuum dewatering = gpm x conductivity - measured

Press Out = gpm x conductivity - measured

Shower water flow = gpm leaving press nip (Xp) + gpm leaving vacuum dewatering (Xu)

Xu = Shower gpm - Xp

Net Web flow out = gpm leaving press nip (Yp) + gpm leaving vacuum dewatering (Yu)

Yu = Net Web flow out - Yp

<u>Uhle box balance</u>

Solids out = Flow x Conductivity

Flow = Xu

Conductivity = Cu

Solids In = Solids from shower water + solids from wet web

Solids from shower water = Shower conc. x Shower water leaving at Uhle box

$= \text{Cs} \times Su$

Solids from wet web = Wet web conductivity x Wet web water leaving at Uhle box

$= \text{WWc} \times WWu$

$\text{Cu} \times \text{Xu} = \text{WWc} \times WWu + \text{Sc} \times Su$

$$Xu = WWu + Su$$

$$WWu = Xu - Su$$

$$Cu \times Xu = WWc \times (Xu - Su) + Sc \times Su$$

$$Su = \frac{Cu \times Xu - WWc \times Xu}{(Sc - WwC)}$$

Su is now the gallons per minute of shower water that is removed in the Uhle box flow. The amount of shower water removed at the press is now the Total Shower flow minus Su. Since the Uhle box flow is known the amount of wet web water removed at the Uhle box is now calculated as the difference between the total and Su. The amount of Wet web water removed at the press can be calculated based on the total press flow if known or a similar material balance at the press nip.

Press Cond x Press flow = wet web cond x wet web flow at press + Shower cond x Shower flow at press

$$Cp \times Xp = WWc \times WWp + Sc \times Sp$$

Press flow = Wet Web flow + Shower flow

$$Xp = WWp + Sp$$

$$Cp \times (WWp + Sp) = WWc \times WWp + Sc \times Sp$$

$$Wwp = \frac{Sc \times Sp - Cp \times Sp}{(Cp - WWc)}$$

The total flow at the press can now be calculated:

$$Xp = WWp + Sp$$

The material balance (conductivity x flow) enables one to calculate the overall flow in and out of each nip. Comparing the measured versus the calculated flows allow the calculation of a flow error that is then applied to the outgoing sheet to accurately determine sheet consistency. This error is applied to the shower flow but could be applied to the measured weir flows but the resulting sheet consistency would be the same.

The measurement of sufficient flows and conductivities in a press section allows a material balance to be performed that will calculate the exiting % solids leaving each press nip. In addition the distribution between the press nip and press fabric dewatering device of water leaving the wet web can be determined. Finally the distribution of shower water applied to the press fabric between the nip and the dewatering device can be determined.

By measuring these flows and conductivities continuously an on-line water balance can be used to optimise the performance of the press section and its components.

CLAIMS

1. A method of monitoring the water balance in a papermachine comprising measuring the electrical conductivity of the water entrained in one or more press felts on entry to a press means, separately measuring the electrical conductivity of the water entrained in the paper web on leaving the press means, and comparing the measured electrical conductivities to determine the material balance.

2. A method according to claim 1 wherein the electrical conductivities are each measured by measuring the concentration of the same specific ions at entry to and on leaving the press means, and the linear relationship between the concentration if said ions are used to determine the electrical conductivity.

3. A method according to claim wherein the material balance is calculated using the following formula:-

   Flow (gpm) x Conductivity IN = Flow (gpm) x Conductivity OUT

4. A method according to claim 3 wherein the IN side of the equation is calculated using the following data:-

   1) Weight of Wet Web, as gpm = f(Tons/day % water)

   2) Wet Web conductivity measured or calculated from previous press nip

3) Showers, as gpm, = f(nozzle size, pressure)

4) Showers conductivity - measured and weight averaged, where f = flow rate, in gpm, as water.

5. A method according to claim 3 or 4 wherein the OUT side of the equation is calculated using the following data:-

1) Vacuum dewatering flow and conductivity, as measured;

2) Press water flow and conductivity, as measured;

3) Wet Web gpm, as Wet Web in <u>minus</u> vacuum dewatering out, <u>minus</u> press water flow.

6. A method according to claim 5 wherein wet web conductivity at the outlet is calculated by solving the equation:-

WWI gpm x WWI cond + Shower gpm x Shower cond = Uhle gpm x Uhle cond + Press gpm x Press cond + (WWI gpm - Uhle gpm - Press gpm) x WWO cond,

wherein WWO cond = $\frac{A + B - C - D}{E}$, wherein

A = WWI gpm x WWI cond

B = Shower gpm x Shower cond

C = Uhle gpm x Uhle cond

D = Press gpm x Press cond

E = WWI gpm - Uhle gpm - Press gpm

7. A method according to claim 1 wherein the solids balance is determined from the following data:-

<u>In</u>

Wet Web in = WWI gpm x conductivity

Shower in = Shower gpm x conductivity, as measured

<u>Out</u>

Wet Web Out = WWO gpm x conductivity, as calculated;

Vacuum dewatering = gpm x conductivity, as measured;

Press Out = gpm x conductivity (as measured);

Shower water flow = gpm leaving press nip (Xp) + gpm leaving vacuum dewatering (Xu), wherein

Xu = Shower gpm - Xp, and

Net Web flow out = gpm leaving press nip (Yp) + gpm leaving vacuum dewatering (Yu), and

Yu = Net Web outflow - Yp.

8. A method according to claim 7 wherein the Uhle box balance is determined from the following data:-

Solids out = Flow x Conductivity

Flow = Xu

Conductivity = Cu

Solids In = Solids from shower water + solids from wet web

Solids from shower water = Shower concentration (Cs) x Shower water leaving at Uhle box (Su)

Solids from wet web = Wet web conductivity (WWc) x Wet web water (WWu) leaving at Uhle box

so that Cu x Xu = WWc x WWu + Cs x Su.

9. A method according to claim 8 wherein Su = the flow rate of shower water in gallons per minute of shower water removed by the Uhle box flow, the amount of shower water removed at the press is determined as Total shower flow minus Su, and the amount of Wet Web water removed at the press is calculated by:-

Press Cond x Press flow = Wet Web cond x Wet Web flow at press, ÷ Shower cond x Shower flow at press,

i.e. Cp x Xp = WWc x WWp + Sc x Sp,

wherein Press flow (Xp) = Wet Web flow (WWp) + Shower flow (Sp),

so that

Cp x (WWp ÷ Sp) = WWc x WWp + Sc x Sp, and

$$WWp = \frac{Sc \times Sp - Cp \times Sp}{Cp - Wwc},$$

and the total flow at the press is determined by Xp = WWp + Sp.

10. A method according to claim 9 wherein the overall flow in and out of

each nip is calculated and the measured versus calculated flows compared to allow calculation of a flow error which is then applied to the outgoing sheet to determine sheet consistency.

11. Apparatus for monitoring the water balance in a papermachine comprising first measuring means for measuring the electrical conductivity of water entering a press means entrained in one or more press felts, second measuring means for measuring the electrical conductivity of the water entrained in the paper web on leaving the press means, and means for comparing the measured electrical conductivity to determine the material balance.

12. Apparatus according to claim 11 further comprising apparatus for measuring and reporting flow rates of water applied to the felt before the press means, and of water collected from the felt and paper web in the press means.

13. Apparatus according to claim 11 or 12 including calculator means adapted to receive said measurements of electrical conductivity and flow rate and to calculate the material balance according to a method as set out in any one of claims 1 to 10.

14. Apparatus according to any of claims 11 to 13 wherein the press means comprise the entire press section of a papermachine, said section comprising a plurality of serially arranged roller nips.

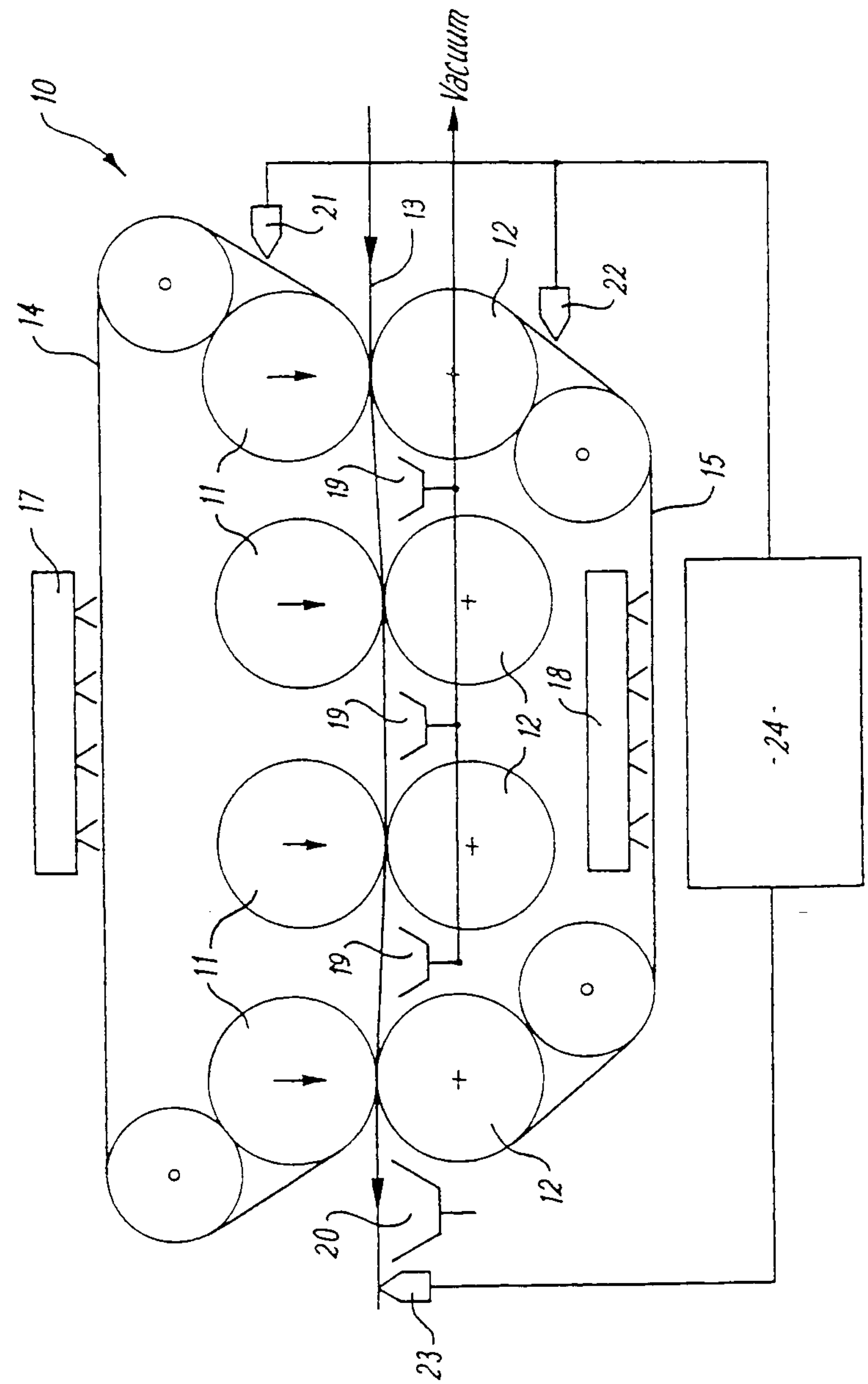
15. Apparatus according to any of claims 11 to 13 wherein the press means comprise a single roller nip.

16. Apparatus according to any one of claims 11 to 15 wherein the means for measuring the electrical conductivity of the water each comprise an electrohydrodynamic induction flow meter.

17. Apparatus according to claim 16 wherein a first such measuring means is located adjacent to an upper press felt immediately before its entry to a press section of a papermachine.

18. Apparatus according to claim 17 wherein a second such sensing means is located adjacent to a lower press felt immediately before its entry to said press section.

19. Apparatus according to claim 18 wherein a further such sensing means is located adjacent a paper web immediately after its emergence from said press section.


Vacuum
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/02325

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01N33/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 462 703 A (PAPER CHEMISTRY LAB INC) 27 December 1991 (1991-12-27) page 6, line 19 -page 11, line 11; figures	1-19
A	WO 95 34810 A (JOHN HEYER PAPER LTD ;PARKER JOHN RUSSELL (GB)) 21 December 1995 (1995-12-21) the whole document	1-19
A	US 3 607 083 A (CHOWDHRY ANIRUDH K) 11 May 1971 (1971-05-11) column 2, line 44 -column 4, line 14; figures	1-19
A	US 3 461 030 A (KEYES MARION A) 12 August 1969 (1969-08-12) column 3, line 20 -column 7, line 62; figures	1-19

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 January 2000	21/01/2000

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International Application No
PCT/GB 99/02328

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 43 21 322 A (PLEVA GMBH) 5 January 1994 (1994-01-05) the whole document	1-19

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/02328

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